NATION SHALL SPEAK PEACE UNTO NATION

RESEARCH DEPARTMENT

THE VISIBILITY OF DELAYED IMAGES IN TELEVISION

Report No. T-086

(1962/18)

THE BRITISH BROADCASTING CORPORATION
ENGINEERING DIVISION

RESEARCH DEPARTMENT

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D. Maurice

G.F. Newell, A.M.I.E.E.
D. Howorth, B.Sc.Tech., Grad.I.E.E.

(D. Maurice)

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SUMMARY

This report describes subjective measurements of the visibility of delayed images superimposed on a 405-line television picture. The visibility of these images, which can occur as a result of a reflected signal caused by a mast or other reflecting object in the propagation path of the direct signal, depends on the amplitude and phase of the reflected signal relative to those of the direct signal. The measurements described here were made using superimposed video signals with a choice of relative polarity. Therefore these results apply to the practical case involving radio-frequency signals only when the two carriers are in exact phase coincidence or exact phase opposition; these are the two most visible conditions.

In these conditions, and with a delay between 3·0 μs and 10 μs, a reflected signal 38 dB smaller than the direct signal will not be more visible than "just perceptible" to 99% of viewers. If its relative amplitude is increased to −32 dB, the reflected signal will be no more visible than "just perceptible" to 75% of viewers. These figures apply for pictures of extreme contrast and which have large areas of uniform background.

1. INTRODUCTION

The suitability of a transmitter site is determined by such factors as its topography and its geographical position with regard to the populated areas to be served by the transmitter. These factors, in addition to that of the availability of suitable unoccupied land, may well point to one location as most suitable for the siting of transmitter masts for a particular area. In these circumstances, if the broadcasting authorities are unable to share the same mast, two masts may be erected at sites separated by, say, a quarter of a mile to one mile. Such close spacing would prevent the direct signal and that reflected by the other mast from being separated by the directivity of a receiving aerial, such separation being, in any case, most undesirable if multi-programme services are required. The difference between the two propagation paths will have a maximum value for receiving sites which, geographically, are in line with the two mast sites and on the far side of the "transmitting" mast from the "reflecting" mast. The time delay of the reflected signal would, in these conditions, be approximately 2·5 μs for the quarter-mile spacing and 10 μs for the mile spacing of the masts. The delayed image would be displaced to the right of the direct-signal picture, and would have the same polarity as the direct picture if the effective propagation-path difference consisted of an integral number of wavelengths. It would have an inverted polarity, or negative image, if the path difference comprised an odd integral number of half-wavelengths. If the path difference included an odd integral number of quarter-wavelengths the delayed image would consist mainly of outlines contained in the direct picture.

In an earlier report[1] it was stated that delayed images, caused by reflections in an imperfectly matched feeder, should be restricted in amplitude to 38 dB below that of the direct signal. On the other hand, Post Office reports[2,3] indicate that if such a reflected signal were 31 dB smaller than the direct signal it would be invisible to 50% of experienced observers. These reports referred to reflections delayed with respect to the direct signal by not more than 2·0 μs. This limit was determined by the maximum probable length of the feeders being considered. Reflection caused by objects in the propagation path are a well-known phenomenon in television reception and can produce delays considerably longer than 2·0 μs.

The measurements to be described were carried out in order to find what ratio of direct to reflected signal amplitudes would be acceptable with relative delay times between 3·0 μs and 10 μs.

2. SUBJECTIVE MEASUREMENTS

The programme material consisted of twelve excerpts from 35 mm films. The excerpts had durations between one and two minutes and they were displayed as a continuous sequence lasting about eighteen minutes. The "stills" reproduced in this report were selected from the excerpts to illustrate the types of programme used. These are not claimed to represent a balanced cross-section of television programmes but they are typical of scenes frequently televised.

The observers consisted of eight engineers experienced in the assessment of picture quality. Experienced observers were used because the authors are of the opinion that, although normally observant viewers may not readily observe a defect when first presented with it in the somewhat unnatural conditions of a test, they may become acutely aware of the defect if it is a permanent feature of their home viewing.

The measurements were carried out with the aid of a high-quality variable delay line.[4] A video signal obtained from a 35 mm telecine was displayed on a 17 in (43 cm) monitor. To this signal was added a delayed version of itself with controllable amplitude and polarity. The peak brightness of the display was about fifteen foot-lamberts (160 asb) and light reflected from the screen in the absence of beam current was about a quarter foot-lambert. The black-level of the display was adjusted to permit delayed signals of either polarity to be visible when the picture consisted of a caption such as excerpt 6. This was done in an attempt to simulate conditions which might result from the use of a receiver having reduced very-low-frequency (or so called d.c.) response.

The observers were asked to assess the visibility of the delayed signals according to the scale:

1. Imperceptible
2. Just perceptible
3. Definitely perceptible but not disturbing
4. Somewhat objectionable
5. Definitely objectionable
6. Unusable

Each excerpt was assessed during its display and the complete sequence was repeated for each of the three ratios of direct-to-delayed signal amplitudes of 26 dB, 32 dB, and 38 dB.

3. RESULTS

Preliminary tests showed that in general the visibility of a delayed signal is not materially dependent upon the delay, within the range $3\mu s$ - $10\mu s$, nor upon the use of either polarity.

TABLE 1

Mean assessments and standard deviation

Excerpt	$\frac{\text{DIRECT}}{\text{DELAYED}}$ = 26 dB		$\frac{\text{DIRECT}}{\text{DELAYED}}$ = 32 dB		$\frac{\text{DIRECT}}{\text{DELAYED}}$ = 38 dB	
No.	Mean	S. D.	Mean	S. D.	Mean	S. D.
1	1·4	0·7	1·25	0·4	1·0	0
2	1·9	0·8	1·0	0	1·0	0
3	1·5	0·5	1·0	0	1·0	0
4	2·4	0·7	2·0	0·5	1·25	0·4
5	2·2	0·6	1·25	0·7	1·1	0·3
6	3·0	0·9	2·1	0·6	1·4	0·5
7	2·1	0·8	1·4	0·7	1·1	0·3
8	1·8	0·7	1·1	0·3	1·1	0·3
9	1·0	0	1·0	0	1·0	0
10	1·4	0·7	1·1	0·3	1·0	0
11	1·2	0·5	1·1	0·3	1·0	0
12	1·0	0	1·0	0	1·0	0

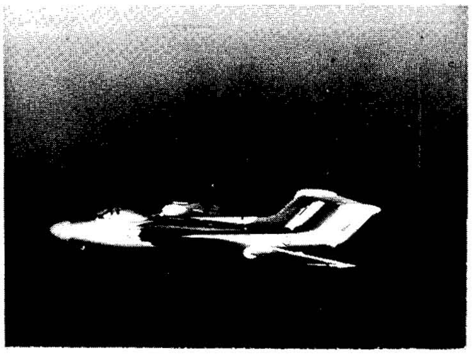
Table 1 shows the mean assessments, according to the above scale, and standard deviations of the eight observers for each of the twelve excerpts. It will be noted that excerpt 6, which consisted of a selection of captions, produced the highest mean assessment. With the exception of excerpts 4 and 6 the mean assessments were all less than 1·5 when the delayed signal was 32 dB smaller than the direct. With the ratio of amplitudes increased to 38 dB, all twelve excerpts produced mean assessments less than 1·5. This indicates that the delayed signal would, in these conditions, be invisible to more than half the skilled observers.

Table 2 shows the probable distribution of assessments in the various grades; this table was computed on the assumption that the results would conform to a Gaussian statistical distribution. A further assumption was that grade 1 had no restriction in the direction of reduced visibility. In other words, grade 1 extended from an assessment value 1·5 to minus infinity.

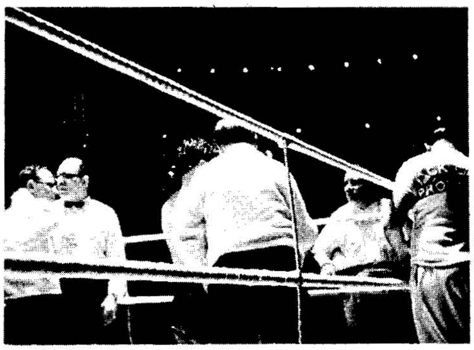
Excerpt 1

Excerpt 2

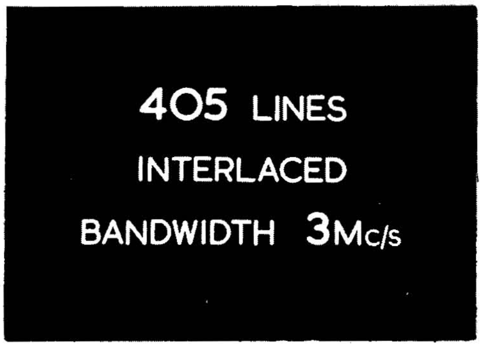
Excerpt 3



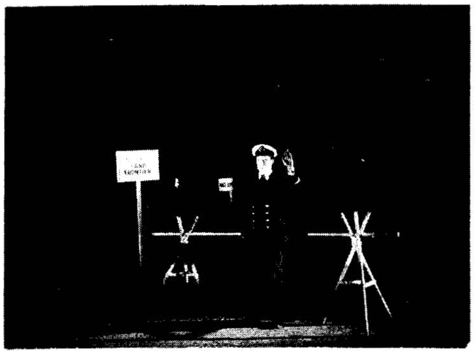
Excerpt 4



Excerpt 5


405 LINES
INTERLACED
BANDWIDTH 3Mc/s

Excerpt 6



Excerpt 7

Excerpt 8

Excerpt 9

Excerpt 10

Excerpt 11

Excerpt 12

TABLE 2

Probable distribution of assessments

Excerpt	$\frac{\text{DIRECT}}{\text{DELAYED}}$ = 26 dB				$\frac{\text{DIRECT}}{\text{DELAYED}}$ = 32 dB				$\frac{\text{DIRECT}}{\text{DELAYED}}$ = 38 dB			
	GRADES				GRADES				GRADES			
No.	1 %	2 %	3 %	4 %	1 %	2 %	3 %	4 %	1 %	2 %	3 %	4 %
1	55	38	6		72	28			100			
2	31	46	21		100				100			
3	50	48	2		100				100			
4	10	46	31	13	16	68	16		72	28		
5	12	57	30	1	64	33	3		88	12		
6	2	23	49	25	16	59	24	1	58	41	1	
7	23	43	30	4	55	33	6		88	12		
8	34	50	15	1	88	12			88	12		
9	100				100				100			
10	56	40	4		88	12			100			
11	50	48	2		88	12			100			
12	100				100				100			
Average	44	36	16	4	74	22	4		91	9		

From Table 2 we can deduce that even when the ratio of amplitudes is 26 dB in the cases of all excerpts, other than excerpt 6, at least 50% of observers would assess the delayed signal as being in grades 1 or 2.

In the case of excerpt 6 it is probable that 25% would consider the reflection as "somewhat objectionable", that is, in grade 4.

When the delayed signal is 32 dB smaller than the direct signal, it is invisible to at least 50% of observers except in pictures typified by excerpts 4 and 6. Even excerpt 6 is assessed by 75% of observers as in grades 1 or 2.

When the delayed signal is 38 dB smaller than the direct signal at least 99% of observers would assess all the excerpts as being in grades 1 or 2.

These results suggest that a ratio of amplitudes of 38 dB would be a nice compromise between engineering economy and imperceptible deterioration of picture quality. On the other hand, a ratio of 32 dB would be sufficient for "acceptable" viewing conditions because at least 75% of skilled observers would always assess the deterioration as being either "imperceptible" or "just perceptible"; this figure is based on the most difficult excerpts and with the majority of programme material the percentage assessments in grades 1 or 2 would be much greater than 75%.

In considering these results it must be remembered that the tests were carried out using video-frequency waveforms and therefore apply to the practical case only when the r.f. signals are either in phase or in opposition to each other. When the phase relationship is other than one of these, the amplitude of the delayed signal will be reduced by the operation of the detector and the visibility will be less than is suggested by the results described here.

4. CONCLUSIONS

The results of these measurements show that although −38 dB is a desirable ratio for the relative amplitude of a reflected signal delayed between 3 μs and 10 μs, 32 dB would probably be acceptable. The most serious deterioration occurs when the picture being transmitted consists of a caption or similar material. Even in this case, only a quarter of experienced observers would be likely to assess the deterioration as "definitely perceptible".

5. REFERENCES

1. "Specification of the Impedance Characteristics of Television Transmitting Aerial Systems", Research Department Report No. E-046, Serial No. 1953/18.

2. "Subjective Quality Tests on a Television Picture with Certain Electrical Distortions", Post Office Engineering Department Radio Report No. 1776.

3. "Further Subjective Quality Tests on Television Pictures with Certain Electrical Distortions", Post Office Engineering Department Radio Report No. 1862.

4. "A Continuously Variable Delay Line for Television Signals", Research Department Report No. T-085, Serial No. 1962/16.

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